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CONSTRUCTION OF AN EXPERIMENTAL SELECTION BATTERY FOR ARMOR SYS--ETC(U)

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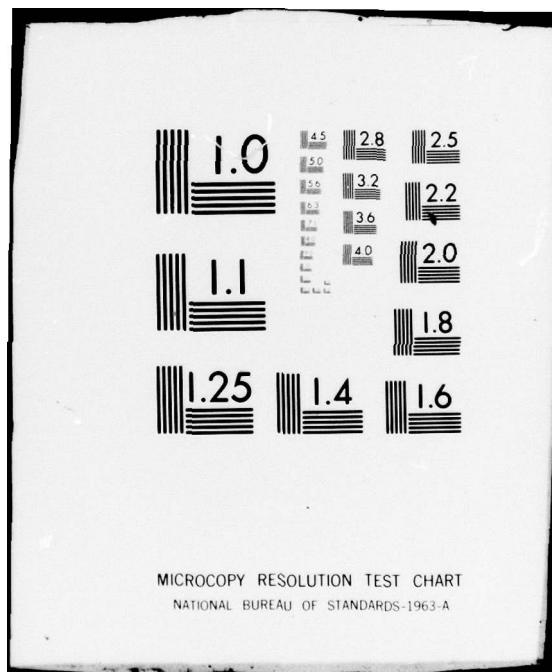
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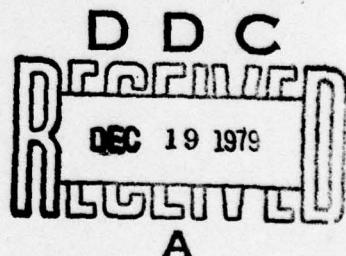
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Research Memorandum 64-2

**CONSTRUCTION OF AN EXPERIMENTAL
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April 1964



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U. S. ARMY PERSONNEL RESEARCH OFFICE

79 12 18 199

Released 27 May 64

Army Project Number
2J024701A723

Fighting Vehicles c-01

(9)

Research Memorandum 64-2

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CONSTRUCTION OF AN EXPERIMENTAL SELECTION BATTERY FOR ARMOR SYSTEMS

(10)

James A. Thomas

Jack Sternberg, Task Leader

(14)

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Submitted by

Philip J. Bersh
Chief, Combat Systems Research Laboratory

(11)

April 1964

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FOREWORD

The experimental selection battery for armor systems described in the present publication was developed under the Task, Identification and measurement of psychological factors related to operation of fighting vehicles, FY 1962 and FY 1963 Work Program. Logistical and support problems were encountered which made continuation of the research program impracticable, and the Task was suspended before validation and standardization of experimental instruments could be undertaken.

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Abstract

CONSTRUCTION OF AN EXPERIMENTAL SELECTION BATTERY FOR ARMOR SYSTEMS

STATEMENT OF THE PROBLEM

Future tactical warfare will require highly mobile and concentrated firepower and increased mobility and dispersion of personnel. To provide the requisite firepower, mobility, and shock action, armor capabilities have been improved and augmented through the development of increasingly complex armament and guidance systems. These systems will make greater demands upon the men who must maintain and operate them. Such human factor problems as confinement, heat, noise, isolation, fatigue, associated with armored vehicle operations will be intensified. In recognition of these problems, USCONARC generated a requirement for human factors research in fighting vehicle operations with the objective of developing ways and means of optimizing the performance of personnel within fighting vehicle systems.

One approach to the optimization of personnel performance is to improve the quality of personnel assigned to Armor through improvement and augmentation of current selection procedures. Current procedures for the selection of armor crewmen are based primarily upon the Armor-Artillery-Engineer Aptitude Area (AE) score derived from scores on two tests of the Army Classification Battery (General Information Test and Automotive Information Test). This selector has proved valid for the armor field as a whole. However, changing qualitative manpower requirements resulting from new system developments and from revised tactics and doctrine dictate a need for reexamination and updating of predictors to include broader measures of personality and motivation as well as differential aptitude measures. Modification of the aptitude area selector for Armor may improve the quality of armor input by selecting personnel whose abilities and other characteristics are more closely aligned with the demands of current and future armor systems.

To date little provision has been made for the systematic assignment of armor personnel to specific vehicle or crew positions. Thus, additional improvement may be effected through second-round selection procedures. Such procedures could serve as a guide to the troop or platoon commander in the assignment of enlisted personnel under his command to specific crew positions. Accordingly, a sub-area of research was established with the specific objective of improving and augmenting current selection procedures for armor personnel.

Specifically, the research had two objectives: to improve the predictive validity of initial selectors of armor input and to develop differential predictors of success in armor crew positions which can be used to augment second-round selection or placement procedures. The first step was the development of a set of experimental measures, the Armor Systems Selection Battery. If the experimental predictors or predictor composites should yield higher validities than the current ACB selector, then the promising measures could provide a basis for revision of the selection measures for the general Armor area. If the experimental measures yield differentially predictive scores in terms of success in specific vehicle or crew positions, the effective tests could be prepared for operational use as aids to Armor unit commanders in assigning enlisted personnel.

DERIVATION OF A PRIORI CORRELATES OF PERFORMANCE IN ARMOR SYSTEMS

Initial orientation of the FIGHTING VEHICLES Task personnel in the basic concepts of armor operations included attendance at a special orientation course at the Armor School, Fort Knox, Kentucky, observation of a number of armor maneuvers, exercises and training tests, and numerous interviews and discussions with knowledgeable armor personnel. Such an orientation resulted in the generation of hypotheses regarding the relationships of certain cognitive and noncognitive functions to performance in armor systems.

COGNITIVE FACTORS

A construction model was developed, based upon the hypotheses generated. A list of behavioral characteristics judged to be related to performance in Armor was prepared. Using job requirements for armor crew positions prepared by the Human Resources Research Office (Baker, 1958) and appropriate Army Training Circulars (1957, March 1958, and May 1958), a modified task analysis was made. Each task in each crew position was analyzed against a list of behavioral characteristics, and requisite behavioral characteristics were hypothesized for each task (Thomas, 1961). The behavioral characteristics were then sorted into groups based upon apparent common cognitive function, and each group was considered a cognitive construct. Constructs and component characteristics were then "plotted" against four crew positions by judged relationship to the positions. The resultant plot yielded an 11 by 4 matrix, shown in Table 1. From this matrix, it is apparent that some constructs could be considered common to all positions and should be related to performance in armored vehicles in general. Others are considered specific to one or more positions and should therefore be differentially predictive of performance by crew position. The resulting matrix (Table 2) served as a model for the selection of specific tests to function as general and as differential predictors in the cognitive part of the experimental Armor Systems Selection Battery.^{1/}

NONCOGNITIVE FACTORS

Constructs derived as indicated above were designed to predict what armor personnel can do in terms of their intellectual or cognitive capacities. In an effort to increase the predictiveness of the battery, a number of noncognitive tests were included to consider such will-do factors as attitudes, interests, and personality characteristics. These WILL-DO factors are likely to become more and more important with future developments in armor systems requiring that the operators perform in isolated work locations with a minimum of supervision, under adverse environmental conditions, and for lengthy periods of confinement and prolonged periods of activity.

^{1/} Psychomotor and perceptual speed tests are herein considered to be cognitive tests.

Table 1

MODEL FOR CONSTRUCTION OF THE ARMOR SYSTEMS SELECTION BATTERY

Behavioral Characteristics	Cognitive Constructs	Psychomotor Coordination	Armor Crew Position			
			Loader	Driver	Gunner	Tank Commander
1. Eye-hand and two-hand coordination.			X	X	X	X
2. Ability to estimate size of objects, quantity of objects; perceive form of objects; estimate speed of moving objects, estimate distance.		Visual Perception	X	X	X	X
3. Attention to many items, carefulness; notices minute changes.		Attention to Detail	X	X	X	X
4. Memory for details, ideas, oral and written directions.	Memory		X	X	X	X
5. Ability to manipulate fixed controls in sequence, to adjust a control knob to obtain a desired change; make precise manipulation which requires speed.		Precision		X	X	X
6. Arithmetic computations, ability to interpret data from tables, instruments, accurately read instruments, dials, tables, graphs, etc., and record the data.		Numerical Facility		X	X	X
7. Skill in using tools, understanding mechanical devices and principles.		Mechanical Know-How	X	X	X	X
8. Maintains spatial orientation.		Spatial Orientation		X	X	X
9. Ability to follow directions.		Adaptability			X	X
10. Ability to perform complex tasks among many distractions.		Multiple Reaction		X	X	X
11. Ability to recognize and define problems, to make decisions, to reason (trial and error).	Reasoning				X	

Table 2

DEVELOPMENT OF COGNITIVE SECTION OF ARMOR SYSTEMS SELECTION BATTERY

Behavioral Characteristics	Armor Crew Position			Tests Selected for Armor Systems Selection Battery			Hypothesized Direction of Prediction
	L	D	G	TC	TC	TC	
1. Ability to estimate size of objects, quantity of objects; perceive form of objects, estimate speed of moving objects, estimate distance.	X	X	X	X	Map Distance, Object Completion I-II, Penetration of Camouflage, Army Perceptual Speed	General, Differential	
2. Attention to many items, carefulness; notices different changes.	X	X	X	X	Attention to Detail, Multiple Reaction Test	General, Differential	
3. Memory for details, ideas, oral and written directions.	X	X	X	X	Associative Memory, Multiple Reaction Test	General, Differential	
4. Skill in using tools, understanding mechanical devices and principles.	X	X	X	X	Mechanical Principles	General, Differential	
5. Ability to follow directions.				X	X	Following Directions Test	Differential
6. Arithmetic computations, ability to interpret data from tables, instruments; accurately read instruments, dials, tables, graphs, etc., and record the data.				X	X	Dial and Table Reading Subtraction and Division	Differential
7. Maintains spatial orientation.	-	X			X	Spatial Orientation, Locations, Objects Identification	Differential
8. Eye-hand and two-hand coordination.		X	X	X	Tapping Test, Two-Hand Coordination	Differential	
9. Ability to perform complex tasks among many distractions.			X	X	Multiple Reaction Test	Differential	

Table 2 (Cont'd)

Behavioral Characteristics	Armor Crew Position				Tests Selected for Armor Systems Selection Battery		Hypothesized Direction of Prediction
	I	D	G	TC	X	Practical Situations, Reaction to Signals	
10. Ability to recognize and define problems, to make decisions, to reason (trial and error).					X		Differential
11. Ability to manipulate fixed controls in sequence, to adjust a control knob to obtain a desired change; make precise manipulation which requires speed.	X	X	X	X	X	Not covered in the battery since these characteristics cannot be adequately measured with a group test.	

The subtlety and complexity of the relationships between noncognitive measures and performance preclude the derivation of specific constructs by task analysis as accomplished for cognitive factors. However, five broad noncognitive areas were selected on an a priori basis: attitude, interest, personal adjustment, social adjustment, and combat adjustment. Comprehensive coverage was given to specific factors within these noncognitive areas in order to test a considerable number of hypotheses generated on the basis of previous USAPRO research (Birnbaum, 1957; Willemin, 1957) and on the basis of participation by task personnel in armor training and exercises.

THE EXPERIMENTAL ARMOR SYSTEMS SELECTION BATTERY

The tests included in the battery were selected or adapted from existing USAPRO tests or obsolete Air Force tests. Consistent with the design and purpose of the battery, component tests were selected to supplement the Army Classification Battery. Table 3 lists the tests included in the Armor Systems Selection Battery. A brief description of the cognitive and noncognitive constructs judged relevant to effective performance in Armor and of the measures selected for inclusion in the battery follows.

PSYCHOMOTOR COORDINATION

A number of psychomotor abilities are required in the concurrent performance of tank operations such as disassembly and assembly of armament, tracking targets, laying and firing the main gun, manipulating the boresight knobs, setting elevation and azimuth indicators, adjusting the aiming circle, and applying data to the computer.

Tests were selected to measure eye-hand coordination and two-hand coordination. Finger dexterity and the ability to make precise adjustments quickly (precision), attributes judged important to armor performance, were not covered because no acceptable group paper-and-pencil tests of these abilities were found to be available.

Two-Hand Coordination (DA Form 6124). This test consists of a series of circles about the size of a dime, arranged in parallel fashion for the left and right hand. The test requires striking fixed targets with hand-held pointers, striking first a left-hand target and then the right-hand target. The test measures two-hand coordination, an ability which is required of the driver in many driving operations such as steering and shifting the gears simultaneously, of the gunner in traversing the turret and applying data to the computer, and of the tank commander in a number of operations.

Tapping Test (PT 3384). This test consists of 240 circles about the size of a dime. Examinees are to place three dots in each circle rapidly, using one hand. The test measures eye-hand coordination, an ability required of the gunner and tank commander in tracking targets and in laying and firing the main gun, and of the driver in certain driving operations.

Table 3

THE ARMOR SYSTEMS SELECTION BATTERY

Test	Number	Time
Booklet 1	PT 4206	50 minutes
Part 1		
1 Object Completion I		
2 Practical Situations		
3 Reaction to Signals		
Booklet 2	4210	85 minutes
Part 1		
1 Mechanical Principles		
2 Spatial Orientation		
3 Locations		
Booklet 3	4214	39 minutes
Part 1		
1 Attention to Detail		
2 Army Perceptual Speed		
3 Associative Memory		
4 Subtraction and Division		
Booklet 4	4217	70 minutes
Multiple Reaction Test		
Booklet 5	4220	126 minutes
Part 1		
1 Following Directions Test		
2 Dial Reading		
3 Table Reading		
4 Activities Inventory		
Booklet 6	4223	33 minutes
Part 1		
1 Map Distance		
2 Object Completion II		
3 Object Identification		
Two-Hand Coordination	DA Form 6124	12 minutes
Tapping Test	3384	6 minutes
Biographical Information Blank	4236	50 minutes
Self-Description Questionnaire, Part 1	4232a	50 minutes
Self-Description Questionnaire, Part 2	4232b	50 minutes
Self-Description Inventory	4229	50 minutes
Penetration of Camouflage	4226	30 minutes

PERCEPTION

Such activities as observing the terrain, searching for enemy targets, estimating distances to perceived enemy targets, estimating speed of movement and number of objects, perception of various stimuli of barely supra-threshold intensity, and estimating the shape and form of objects which might be partially concealed, are primarily perceptual. Six tests of perceptual abilities were included.

Map Distance Test (Booklet 6, PT 4223). This test consists of four maps each marked with a reference point and the location of 12 towns and cities. In each question, the examinee is required to determine by inspection which of two towns named is closer to the reference point. The test is designed to measure the ability to estimate charted distances. This ability is assumed to be highly correlated with ability to estimate physical distances, an ability required of the gunner, of the tank commander in range estimation, and of all crew members in target acquisition, reconnaissance, or in preparation of range cards.

Object Completion I (Booklet 1, PT 4206). This test consists of fifteen standard figures and thirty partially obscured figures. The examinee is required to determine which standard figure corresponds to each test figure. The test is designed to measure ability to identify simple figures within complex designs, an ability required of the entire crew and pertinent to the perception and discrimination of targets located in natural or artificial surroundings with complex backgrounds. The ability is also required in laying and firing the main gun upon these targets by the gunner and tank commander.

Object Completion II (Booklet 6, PT 4223). This test is a modification of the Street Gestalt Completion Test. It consists of a series of drawings of objects from which many of the parts are deleted. Examinee is to select from a list of alternate answers the object which is partially portrayed in the picture. The test measures the ability to perceive the form of an object when only a portion of it can be seen. This ability is important to an armor crew in reconnaissance, in the detection of camouflaged targets, and particularly to the gunner and tank commander in sighting and laying the main gun on such targets.

Penetration of Camouflage (PT 4226). This test consists of six page-size drawings of military activities. Concealed faces have been worked into the context of each scene. The examinee is to detect the camouflaged faces in each picture and to mark their location in terms of grid coordinates. The test is designed to measure the ability to distinguish a pattern from a confused background. This type of perceptual ability is assumed to be important to an armor crew as a whole in the detection of targets which are camouflaged, and especially to the gunner and tank commander in the laying and firing of tank weapons at such targets.

Army Perceptual Speed Test (Booklet 3, PT 4214). This is a cognitive test requiring the examinee to match identical groups of objects. Given five standard groups, the examinee is required to match each of four test groups with one of the

standard groups. There are twelve sets of standard groups. The test measures the ability to spot quickly similarities and differences in visually presented stimuli, an ability fundamental to many perceptual activities required of the tank crew.

Attention to Detail (Booklet 3, PT 4214). This test consists of a number of rows of the letter "O" randomly intermingled with the letter "C". The examinee is required to mark out the "C's". The test is a measure of the ability to follow instructions in finding an important detail. The underlying ability is assumed to be related to an armor crew's ability to attend to small details of a perceptual nature and to notice differences quickly, as in maintenance checks, dial reading, and the like.

MEMORY

Armor crewmen must carry with them mental images of certain information essential for the success of their missions. Much of this material is nonverbal or pictorial, consisting of recently acquired information such as maps of enemy territory with landmarks, targets and other identifying features. Some of the material may be verbal, such as oral instructions from the tank commander or the platoon leader, and may contain code words, route, or coordinated rendezvous.

Associative Memory (Booklet 3, PT 4214). This test is based on the traditional paired-associate item. The examinee is required to memorize two-digit numbers associated with object names. The test is designed to measure the ability to associate certain responses with key stimulus words, and is related to the ability to associate or to remember oral instructions, rendezvous, or key action coordinates, code names, call signals, etc.--requirements of all crewmen in tank operations.

NUMERICAL FACILITY

In the course of armor operations, crew personnel need to be facile with numbers in a variety of activities such as using and adjusting the aiming circle, estimating range and azimuth, computing elevation and azimuth on the appropriate devices, preparing range cards, estimating range and deflection in laying gun for direct and indirect sighting, firing the main gun, reading and interpreting the tachometer and other dials in the driver's compartment, and using the firing tables for the main gun. The tests below measure ability to perform simple arithmetic functions quickly, to read from simple charts, tables and dials, and other numerical operations similar to those encountered in various armor activities.

Subtraction and Division (Booklet 3, PT 4214). This test measures the ability to accomplish simple numerical operations such as subtraction and division. These operations are similar in principles to those encountered in gunlaying, preparing range cards, etc., by the gunner and tank commander.

Dial Reading (Booklet 5, PT 4220). This test consists of a series of meters with a needle indicating a reading. The examinee is required to read the dial to the nearest whole number. The test measures ability to read and interpret dials, an ability required by the driver in driving, the gunner in reading azimuth scales and in using the computer, and the loader in tuning the radio, and other similar operations.

Table Reading (Booklet 5, PT 4220). This test consists of two large rectangular tables of 35 rows and columns. Examinees are to locate the correct row and column for a given problem, and to identify the number at the intersection from five possible answers. The test is designed to measure the ability to read tables, and measures the ability required of the gunner in using firing tables for the main gun.

SPATIAL ORIENTATION

In the operation of a tank at night or in the "buttoned-up" position, the crew is deprived of the normal cues for orientation. As a consequence, a tank commander or driver may become disoriented in space and location. A major aspect of spatial orientation is the perception of changes in terrain or in general surroundings as a result of change in position of the observer. The tank commander and driver may use overlays of attack and route marches, terrain maps, etc., in routine missions. It is important for them to be able both to visualize the synthesis of a two-dimensional pattern into a three-dimensional object, as in map reading, and to analyze a form into an appropriate pattern, as in preparing range cards. The tests described below were selected to measure the kind of spatial orientation judged to be important to armor systems performance.

Spatial Orientation (Booklet 2, PT 4210). This test has 50 items, each composed of two pictures showing what the examinee would see if he were riding in a motorboat. The examinee is required to figure out what change in position of the boat has occurred between the top and bottom pictures. The test measures the ability to perceive changes in terrain and to distinguish direction of motion, an ability important to drivers in driving the tank, and to tank commanders in following prescribed routes, especially at night or in the "buttoned-up" position.

Object Identification (Booklet 6, PT 4223). This test is a modification of the Thurstone Flags Test. It contains silhouettes of planes, trucks, tanks, and ships. The examinee is to identify which of the five alternative silhouettes matches the standard silhouette on the left. The test measures the ability to manipulate images in space, an ability assumed to be related to a tank commander's and driver's ability to maintain proper orientation in space without normal clues.

Locations Test (Booklet 2, PT 4210). This test consists of twelve large photographs with four sub-areas photographed from different positions. The examinee must identify the location of the sub-area photograph on the large one, indicating the letter on the correct area as shown on the large picture. The test is designed to measure ability to perceive and utilize minimal cues from the surrounding environment, a spatial ability related to the driver's and the tank commander's facility for orientation during limited visibility or during operation while buttoned-up.

ADAPTABILITY

In the operation of a tank, the tank commander and the gunner must be able to concentrate upon tasks of varying complexity amid various kinds of distractions. They must be able to attend to different kinds of stimuli such as visual and auditory presented simultaneously. They must be able to react quickly to different situations and to adapt quickly to rapidly changing situations. Two tests of complex factorial structure were selected to measure this type of reaction and adaptability.

Following Directions Test (Booklet 5, PT 4220). This test of 169 items is designed to measure the ability to follow several different sets of instructions simultaneously. The examinee is required to respond differentially to several different stimuli given together or in succession; some responses are conditional upon certain stimuli occurring in combination. The test situations are similar in principle to such actions as aiming and firing the main gun on order from the tank commander, or to carrying out mission-type orders where decisions must be made on the basis of the situation at hand.

Multiple Reaction Test (Booklet 4, PT 4217). Printed tasks are interspersed with tasks given by tape recorder. Tests include dial interpretations, code reaction, and attention span. The test measures the ability of the examinee to perform a variety of tasks and to adapt to rapidly changing situations and instructions. The test situations are similar in principle to actual armor operations in which the tank commander and the gunner are constantly interrupted in the performance of their tasks and must perform their duties in the midst of many distractions and interruptions, or are required to interrupt one task and then to return to it at a later time.

MECHANICAL KNOWLEDGE

An understanding of fundamental principles of mechanical knowledge appears to be basic to a number of armor activities such as the assembly, disassembly, and first echelon maintenance of armament, power plant, and track suspension subsystems.

Mechanical Principles Test (Booklet 2, PT 4210). This test consists of twenty Bennett-type items. It is designed to measure the ability to understand mechanical principles, an ability related to effectiveness of first echelon maintenance of the power plant, including disassembly and assembly of the armament subsystems performed by all crew members.

REASONING

The relevance of this attribute is reflected in such human factor demands upon the tank commander as determining alternate plans for attacking an objective, selecting targets of opportunity, determining ways of securing an assigned sector of terrain, determining the necessity for--and the proper alternate method

of--adjusting fire in the event of continued missing line-of-fire targets, deciding what to report, or determining alternate courses of action in emergency situations.

Practical Situations Test (Booklet 1, PT 4206). This test, designed to measure general reasoning ability, presents 25 verbal problems requiring the examinee to choose the correct solution from among four possible action patterns.

Reaction to Signals (Booklet 1, PT 4206). This test of 270 items measures the ability to learn a system of signals and appropriate responses. The examinee is required to make particular configurations on his answer sheet in response to each of six different signals.

BIOGRAPHICAL DATA

Interviews with combat-experienced tank commanders in regard to the type of personnel they would select for their tanks frequently brought the comment: "Give me a country boy who has puttered around with farm machinery" or "Give me someone who has built himself a hot rod". A study by HumRRO on combat fighters indicated that fighters participated in more "doer" type activities than did non-fighters (Egbert, et al, 1957). Further, Guilford (1954) has indicated that certain BIB items were more predictive of performance in some Air Force jobs than any other type of noncognitive measure. USAPRO studies have illustrated the value of the BIB item in predicting performance in certain Army specialties.

Biographical Information Blank (PT 4236). This noncognitive self-description measure was constructed to reflect biographical data judged pertinent to performance in Armor. The test contains 163 items on socio-economic status, family relationship, tool and weapon familiarity, types of entertainment or recreation level preferred, and level of participation in sports and clubs. Although most items included in the test were modified in some respect, the original sources are listed below.

Personnel History Form (PT 3161)

Leadership Characteristics Inventory (PT 4011)

Schedule of Personal Options (A + B) (PT 3714, PT 3715)

Self-Description Inventory (PT 3842)

PERSONALITY

The aptitude area selector for Armor contains the General Information Test, GIT, a test designed to reflect interests and general knowledge of outdoor activities, athletic hobbies, etc. Inclusion of this test in the ACB has yielded definite improvement in the prediction of performance in Armor-Artillery-Engineer

jobs. However, in the case of armor personnel, it has been hypothesized that even greater improvement could be made through the additional measurement of the individual's tendencies to react toward certain stimuli, his predispositions, and his habitual modes of response--in other words, his social, personal, and combat adjustment. A large number of personality constructs have been selected for the Armor Systems Selection Battery, including the usual ones of anxiety, aggression, and emotional stability, to provide a broad coverage of personality characteristics from which those pertinent to armor performance can be isolated. These constructs are covered in four test booklets, three of which are reprints of existing USAPRO instruments. The fourth was constructed specifically for the battery.

Self-Description Questionnaire, Part 1 and Part 2 (PT 4232a and PT 4232b). This instrument consists of two booklets, each containing 150 items which were selected to reflect personality characteristics judged to be related to combat performance. The general content areas are: personal maturity, personal responsibility, and personal vigor (Katz, 1961).

Activities Inventory (Booklet 5, PT 4220). This test is a noncognitive measure of interests, containing 260 self-description like-dislike items (Rosenberg, 1961).

Self-Description Inventory (PT 4229). This test contains 164 items selected or constructed to reflect personality characteristics judged to be related to performance in armor systems. The general content areas are freedom from manifest anxiety, distractability and indecision, "doer" activity, tenacity of purpose, and authoritarianism vs acquiescence. The sources of the items included in this inventory are as follows:

- Taylor Scale of Manifest Anxiety
- Self-Description Blank - RN (PT 3847)
- Self-Description Inventory - SDI-RA (PT 3426)
- Personal Description Inventory - PDI-1 (PT 3159)

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